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UTILIZATION OF IDLE EQUIPMENT IN DISTILLERIES FOR PRODUCTION OF WHITE POTATO FLOUR

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INTRODUCTION

The current demand for white potato flour for Europe far exceeds the capacity of white potato flour factories in this country. As a consequence, idle equipment, such as cookers and drum driers in distilleries and food processing plants, is being used for producing white potato flour.

This circular describes how such equipment may be utilized. The information was obtained by surveys of methods currently employed and by pilot-plant experiments conducted at this Laboratory. The recommended procedure, however, may require some modification to utilize the equipment available in any given plant.

PROCESS AND EQUIPMENT

The process recommended consists in the following operations. The potatoes are washed in a conventional-type washer to remove dirt and stones, then processed in a hot lye bath and washed with high-pressure water jets to remove the skins. They are then conveyed over an inspection table where defective potatoes are trimmed or removed. The potatoes are processed with low[illegible]e steam in batch cookers until soft and then whipped through a hammer mill to produce a material having a thick, creamy consistency. The success of the process depends largely on the whipping action in the hammer mill.

1/ For information relative to the availability of potatoes, the price and market for potato flour, and standards for quality, inquiries should be addressed to Potato Division, Fruit and Vegetable Branch, Production and Marketing Admin., United States Department of Agriculture, Washington, D. C.

The creamed potatoes are pumped to a double-drum rotary drier, the drums of which rotate toward each other and downward. The dried product is conveyed to a hammer mill, ground, screened and bagged.

Washing

Potatoes are fed by flume or conveyor or dumped by hand into the feed chute of the washer. The washer shown in Figure 1 is essentially a long trough fitted with screen or slat false bottom and divided into three or more compartments. A shaft with agitator paddles runs the entire length of the washer. Each compartment is provided with connections for filling the trough with running water and caring for the overflow and discharge of dirt and small stones. Large stones are removed periodically by hand from each compartment. The agitation by the paddles causes the potatoes to rub against each other, and the friction removes any adhering dirt or other foreign matter. The paddles carry the potatoes continuously through the washer, and a lift paddle at the end of each section transfers the potatoes from one compartment to the next, leaving the stones behind. From time to time the accumulated dirt and small stones are flushed out of the bottom of the compartments.

Washers of the type described do an excellent job and are extensively used by the potato products industry, both in this country and abroad. Other types of washers are satisfactory if they give the potatoes a vigorous agitation in running water and are provided with means for removing stones, soil, and any other foreign material.

Peeling

Peeling is the next operation in the process. As the potatoes leave the water, they are picked up by a conveyor and discharged into a hot lye bath of 10 to 14 per cent caustic and processed about 2 to 4 minutes at a temperature close to the boiling point of the solution.

FLOW SHEET FOR POTATO FLOUR MANUFACTURE

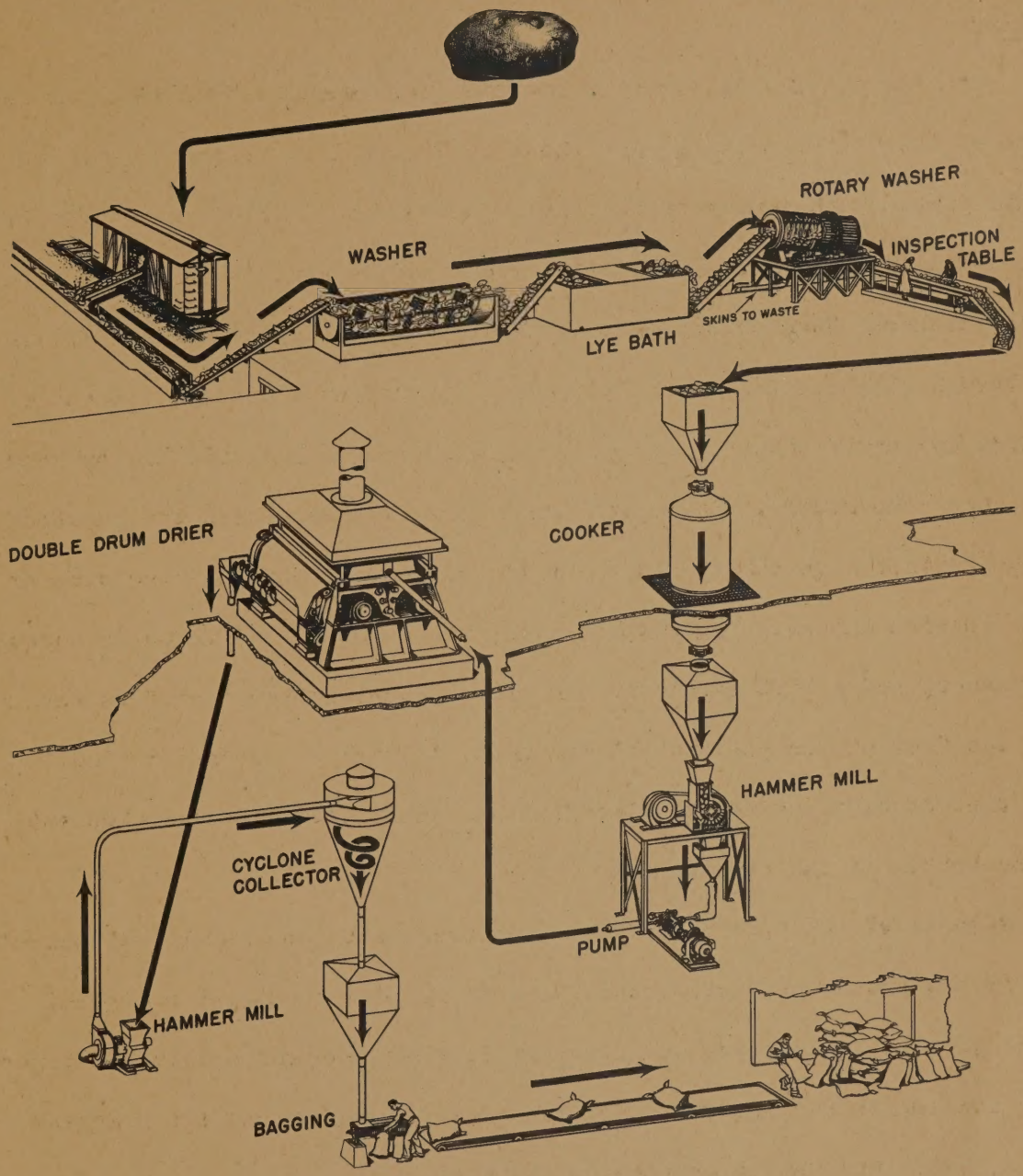

FIGURE NO. I

The peels are loosened enough by the hot caustic solution to be removed by a subsequent washing operation. As the potatoes are conveyed from the lye bath to the rotary drum washer, the excess caustic is washed away by water sprays. Within the rotary drum washer, the potatoes are tumbled and washed with water sprays at a pressure of 80 to 100 pounds per square inch which scours the skins from the potatoes.

Lye peeling baths with caustic concentrations of 3 to about 50 percent have been reported in the literature. Lye solutions of the concentration and temperature required for lye peeling are hazardous, and goggles and rubber gloves should be worn by the operators.

Lye peeling, an economical method,2/ is shown on the flow sheet. Abrasive peeling and stem peeling may also be used. Both batch- and continuous-type abrasive peelers are available. The batch-type abrasive peeler has been used extensively in canning factories and in the kitchens of hotels, restaurants, and institutions. It consists of a cylindrical container with a revolving plate as the bottom. The revolving plate, or peeling disk as it is called, is coated with an abrasive material such as silicon carbide and is power rotated. In most machines, the walls of the container are also coated with an abrasive material. About one bushel of potatoes may be handled by the machine in one batch, and the peeling is accomplished in approximately one minute. Wash water is sprayed on the potatoes continuously to carry away the skins as they are removed. The continuous-type abrasive peeler probably would be better for a potato flour plant than the batch type. It consists of several compartments through which the potatoes pass. In each compartment are several silicon carbide coated rolls, which rotate at high speed.

2/ "Lye Peeling Pays Off"; Ray S. Dunlap; Food Industries, vol. 16; pp. 969-971 and 1044-1046; December 1944.

The last compartment contains rolls with a fine coating of abrasive for finishing. The potatoes move continuously through the several compartments, the peels being removed by the abrasive action of the rotating rolls. Sprays of water are continuously played on the potatoes to carry away the peelings. With abrasive peelers, the material losses are rather high, and with the batch-type peeler, labor costs are high.

Steam peeling is a rather recent development. The potatoes are heated with high-pressure steam for a short period to loosen the skins and then the loosened skins are washed off with high-pressure water sprays. The heating may be done in a rotating steel retort with steam at about 60 to 80 pounds per square inch for about 1-1/2 minutes. This cooks the thin outside layer. The potatoes are then discharged from the retort and conveyed to the high-pressure water washer. As they pass through the washer, they are rotated by rubber-coated rollers running at different speeds, and high-pressure jets of water above the rollers remove the skins. The material losses are about the same as in lye peeling, but labor costs would probably be higher. On the other hand, salvaging and drying the potato peels for stock feeds is a possibility.

After peeling, the potatoes pass over an inspection table, where any bad potatoes are removed and any necessary trimming is done.

Cooking

Some distilleries, especially those which have used potatoes as a source of alcohol, may find it convenient to disintegrate the potatoes and then cook the slurry. However, this is not recommended. The disintegrated potatoes discolor so rapidly that the finished flour is usually dark. So far no practical means has been found for removing this discoloration. In the manufacture of white potato flour, it has long been the practice to

cook the potatoes whole, and our experience with alternate procedures has confirmed the desirability of this method.

Practically all distilleries and food-processing plants have equipment suitable for cooking potatoes, or that can be readily adapted to this purpose. For example, a vertical, cylindrical digester having a conical bottom equipped with a discharge gate is well suited for this use. Likewise, atmospheric-pressure steam cookers give good results. The cooker should have a working capacity of at least 1 cubic foot for each 7 square feet of drum drier surface. Thus, a double-drum drier with rolls 42 inches in diameter and 10 feet long and having a surface area of 220 square feet, would require a cooker with a volume of at least 32 cubic feet. This relationship is based on a 40-minute cooking time with a cycle of 1 hour per batch. A hopper should be provided over the cooker to hold potatoes from the inspection belt while the preceding batch is being cooked.

Potatoes cooked at low steam pressure do not discolor as much as those cooked at higher pressures. A method found satisfactory at this laboratory for cooking U. S. No. 1 whole peeled potatoes consists in cooking them 30 minutes in steam at a pressure of 2 to 3 pounds per square inch, then increasing the steam pressure to 10 pounds per square inch for an additional 10 minutes. Smaller potatoes can be cooked in less time. The condensate should be removed through a steam trap to reduce the amount of water to be evaporated on the drier.

Another method [3] consists in cooking small peeled potatoes and 3/4-inch slices at 210° F. in a continuous atmospheric-pressure steam cooker for approximately 30 minutes.

3/ "Instant Mashed Potatoes from Dehydrated Granules" J. W. Greene, Grant C. Marburger and F. A. Rohrman; Food Industries, December 1947; pp. 86-89 and 213-215.

Noel [4] states that potatoes should be cooked in steam at a pressure of 15 pounds per square inch for 15 to 20 minutes, or until soft.

The cooked potatoes are discharged from the cooker into a wooden hopper located above a hammer mill in which the potatoes are to be disintegrated. A wooden or insulated cover should be provided for the hopper to prevent the potatoes from cooling.

Disintegrating

The method used to disintegrate cooked potatoes determines to a great extent how satisfactorily double-drum driers can be employed for the manufacture of potato flour. It was found at this Laboratory that a hammer mill having no screen and equipped with 5/16-inch blunt hammers - 10 inches tip to tip - and operated at 3500 revolutions per minute, which is equivalent to a peripheral speed of 9150 feet per minute, can be used satisfactorily. When equipped with three rows of seven hammers each, this mill can whip at least 4,000 pounds of cooked potatoes per hour, which is more than is required to supply three double-drum driers 42 inches in diameter and 10 feet long. Mere mashing of the cooked potatoes is not satisfactory. Thorough creaming is essential to produce a product which will uniformly coat the drums of driers of the type customarily employed for distillery wastes.

The whipped potatoes are discharged from the hammer mill into a wooden or insulated storage tank equipped with a cover. It is extremely important to keep the temperature of the potatoes above 150° F. from the time they are cooked until they are delivered to the drier. This hot product can be transferred to the drum driers with a positive delivery-type pump with crescent impellers. Other positive delivery pumps may prove equally satisfactory.

4/ "Manufacture of White Potato Flour", W. A. Noel, Chemical Age, vol. 30, p. 381, September 1922.

Drying

The potato flour industry uses a special type of drier. It has a drum 4 feet in diameter and 8 feet long, which rotates about eight revolutions per minute and is heated with steam at about 100 pounds per square inch. The drier is equipped with four or five auxiliary rolls, which range from 4 to 8 inches in diameter. These rolls, which are not heated, are held close to the large drum by springs. The tension can be relieved by means of manually controlled levers. The small rolls distribute the mashed potatoes over the hot drum and remove pieces of potato skin, which adhere to the cold rolls. The small rolls are cleaned periodically by the operator. The dried product is removed continuously from the large drum by means of scraper knives.

Distilleries and most food-processing plants do not have this type of drier. Many of these plants, however, are equipped with atmospheric double-drum driers. The drums of these driers rotate toward each other and downward. The size varies, but many of them are 42 inches in diameter and 10 feet long. The thickness of the layer deposited on the drums is controlled by adjusting the clearance between them. This is in contrast to conventional potato flour driers, where the thickness is governed by the pressure exerted on the drum by the auxiliary rolls.

The chief problem encountered in adapting the double-drum drier to the manufacture of potato flour is to process the cooked potatoes so that they can be readily fed to the drier, and uniformly coat the drums.

The drying tests made at this Laboratory were performed on a pilot-plant double-drum drier that had drums much smaller than commercial driers. The drying time on the drums, however, was the same as that obtained with the larger driers; the steam pressure, 90 pounds per square inch, was about the same as that frequently used in large driers; and the clearance

between the drums was the same as that usually employed in large-scale work.

One manufacturer has found that when the cooked potatoes are creamed in a hammer mill according to our recommendations the product satisfactorily coats the rolls of large double-drum driers which have higher peripheral speeds (because of their size) than our small unit. Thus the results obtained with the pilot-plant drier are reproducible in commercial operation.

The best drying rate with the small laboratory unit was obtained when the drums were operated at about five revolutions per minute and spaced about 0.010 inch apart. Under these operating conditions, evaporative rates of 5 to 5.5 pounds of water per square foot of drum surface per hour were obtained. That is, 1.1 to 1.2 pounds of product, containing 5 percent moisture, were obtained per square foot of drier surface per hour. It is believed that commercial drum driers equipped to remove water vapor more efficiently, and thus prevent the potato flakes from rehydrating, would have higher evaporative rates. On this basis, a double-drum drier having rolls 42 inches in diameter and 10 feet long should produce at least 5,800 pounds of product every 22 hours. This quantity of product would require about 18 tons of raw potatoes daily.

In addition to the usual factors contributing to efficient drier operation, it is important in making potato flour to keep the surface of the drums smooth and polished and to sharpen the doctor knives daily. If these conditions are met, scorching will be minimized. It must be emphasized that to achieve a uniform creamy feed that will adhere to the drums, the temperature of the potatoes from the time they leave the cooker until they are fed to the drier must be maintained above 150° F.

Pulverizing and Bagging

Fine (60 mesh) flour can be produced by milling the dried product in

a hammer mill equipped with a 60-mesh screen. The screen must fit snugly and have no defects that would permit particles larger than 60 mesh to pass through the mill. As the flour leaves the mill, it is blown to a cyclone dust separator, from which it is discharged to a bagging bin. It is usually bagged in good quality burlap bags provided with crepe liners.

If a granular product is desired, it can be produced in the manner described for making 60-mesh flour except that the hammer mill should be equipped with a screen having openings larger than 30 mesh to minimize the amount of fines produced. It would also be necessary to pass the product from the mill over a vibrating screen equipped with a 30- and a 60-mesh screen. The material that passes through the 30-mesh screen and remains on the 60-mesh screen is a granular product. That which passes through the 60-mesh screen is fine flour. That which remains on the 30-mesh screen should be reground. The amounts of fine and granular product produced depend on the size of the screen used in the hammer mill.

The hammer mill should have a capacity of at least 3 tons per day for each double-drum drier with rolls 42 inches in diameter by 120 inches long.

Attrition mills may be used for grinding the flakes. If such mills are used, it will be necessary to provide 30-and 60-mesh classifying screens or reels.

FINISHED PRODUCT

The product obtained by this method is light cream in color and has a typical potato-flour flavor. However, it has not been evaluated in bakery products.